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ABSTRACT

REPORTED IS A STUDY TO EVALUATE THE EFFECTIVENESS OF THE USE OF SEVERAL TYPES OF MATERIAL AND SEVERAL DIFFERENT APPROACHES TO TEACHING OF BASIC MATHEMATICS TO NINTH GRADE STUDENTS. A SUGGESTED OUTLINE IS GIVEN FOR THE IMPLEMENTATION OF PROGRAMMED BASIC MATHEMATICS AS WELL AS OTHER PROGRAMMED MATERIAL IN INDIVIDUAL SCHOOLS. THE OUTLINE CONSIDERS SUCH FEATURES AS ASSIGNMENT PROCEDURES, TESTING, GRADING, PROMOTION, TEACHER ROLE, AND COURSE CONTENT. (RP)

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A Study In The Use

of

PROGRAMMED MATHEMATICS MATERIAL

at

Ninth Grade Level

May, 1967

Instructional Media Center

Dickinson Public Schools

Dickinson, North Dakota

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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TABLE OF CONTENTS

	Page
PREFACE	iii
INTRODUCTION	
PURPOSE	1
ASSUMPTIONS	1
THE PROBLEM	1
RATIONALE	3
DICKINSON PUBLIC SCHOOLS - CONCEPTS	4
SOLUTION	5
IMPLEMENTATION AT DICKINSON CENTRAL HIGH SCHOOL	6
TEACHER ORIENTATION	6
QUESTIONS ABOUT THE PROGRAMMED MATERIAL	6
QUESTIONS ABOUT THE USE OF PROGRAMMED MATERIAL	15
I. No Teacher??	15
II. Lockstep	16
III. Lockstep broken	18
IV. Optional methods of teaching	19
1. Individual progress class	20
a. Assignment procedures	20
b. Testing procedure	20
c. Grading procedure	20
d. Promotion procedure	20
e. Teacher role	21
f. Course content	21
g. Points to consider	22

		Page
2.	"Block of Time" class	23
	a. Assignment procedure	23
	b. Testing procedure	23
	c. Grading procedure	24
	d. Promotion procedure	24
	e. Teacher role	24
	f. Course content	25
	g. Points to consider	25
3.	A combination of one and two	26
V.	Which is the best?	26
	SHOULD WE USE PROGRAMS IN OUR SCHOOL	29
I.	Administrative change	29
II.	Changes in teachers role	29
1.	Teaching with programs, knowing the subject matter	30
2.	Preparing the student to learn with programmed material	31
3.	Ways of using programmed materials	35
4.	Appraisal of students	37
III.	Deciding where to use programmed instruction	39
	EVALUATION AND RECOMMENDATIONS	42
	Student Evaluation	42
	Recommendations	43
	CONCLUSION	44

PREFACE

The Instructional Media Center, Dickinson, North Dakota, is completing its first year of operation. During that first year, a number of curriculum projects largely in cooperation with the Dickinson Public Schools have been undertaken. The results are being made available to the area schools of Southwestern North Dakota.

The Instructional Media Center makes available materials--commercially produced or locally designed and prepared. The prime emphasis of adequate materials, however, is based on curriculum content and solid needs arising thereof.

In each curriculum project described materials are needed that have not been readily available previous to existence of the Media Center. The less expensive materials would, of course, be provided at the local district level. These initial projects were made possible primarily through funding by the Dickinson Public School District using local, N.D.E.A., and an Arts and Humanities Grant, as well as the Instructional Media Center.

Each curriculum innovation is prepared in a separate brochure and is available from the Media Center for use in the area schools. Materials are identified in each project that may be available for Southwestern North Dakota schools for instructional use from the Instructional Media Center.

The projects now completed are as follows. Credit is given to the individual instructor and their employing institution

who worked diligently in the initial preparation and instituting the project.

I. An Ungraded Primary Level Science Program--levels one through six (Grade 1-2-3)

Mr. Myron Freeman--Professor of Biology, Dickinson State College

Mr. John Anderson--Professor of Biology, Dickinson State College

II. La Familia Fernandez--a complete systems approach to the teaching of Spanish

Mrs. Sheryl Novacek--Dickinson High School Faculty

III. Deutsch Durch Audio-Visuelle Methode--an audio-lingual approach to the teaching of German

Mr. Eckhart J. Reid--Chairman, Dickinson High School Foreign Language Faculty

IV. An Instructional Unit in Mass Media for use in communication classes at the secondary level

Mrs. Agnes Oxton--Chairman English Department, Dickinson High School

Mr. Ed Sahlstrom, Instructor, Dickinson High School

V. A Study in the Use of Programmed Mathematics Material at the Ninth Grade Level

Mr. Larry Rafferty, Chairman, Mathematics Department, Dickinson High School

Mr. Robert Scott, Dickinson High School Faculty

Mr. James Peters, Dickinson High School Guidance Department (Evaluation Assistance)

The Instructional Media Center takes a special pride in having been able to have had the fine professional cooperation and help by these most able people.

General coordination of the projects has been under the direction of the curriculum coordinator of the Instructional Media Center, Mr. Vernon F. Hagen. Special consultive assistance and help has been provided by Mr. Kirian L. Dooley, and Mr. George Fors of the North Dakota Department of Public Instruction.

Special thanks is due the administrative leaders of the institutions who made their staff available, Dr. O. A. DeLong, President of Dickinson State College and Cecil B. Risser, Principal of Dickinson High School. Certainly any activities undertaken by the Instructional Media Center must also give credit to the educational leadership asserted by Donovan B. Benzie, Superintendent of Schools, Dickinson, North Dakota.

It is the sincere hope of the Instructional Media Center that these curriculum innovations and studies will be coordinated into the academic curriculum in Southwestern North Dakota.

The Instructional Media Center is thankful it can continue to supply many of the materials needed to implement these programs.

Gordon L. Paulsen, Director
Instructional Media Center
June 15, 1967

The work presented or reported herein was performed pursuant to a grant from the U.S. Office of Education, Dept. of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S.O.E. and no official endorsement by the U.S.O.E. should be inferred.

PURPOSE

The purpose of this study is to evaluate the effectiveness of the use of several types of material and several different approaches to teaching of Basic Mathematics to ninth grade students. This study is not an attempt to determine whether programmed basic mathematics will replace the teacher.

A secondary purpose of this study is to provide an outline for the implementation of programmed basic mathematics as well as other programmed material in individual schools.

ASSUMPTIONS

It is assumed that superiority of instruction will be essential for the successful accomplishments of teaching the youngster who has math weaknesses regardless of whether conventional or programmed material is used.

Each youngster, it is assumed, will have voids and scattered chaotic understanding of basic mathematics. How then, does a teacher provide individualized remedial instruction for thirty youngsters? It is reasonable to assume that each child will need a individualized educational diet.

THE PROBLEM

Dickinson Public High School receives its youngsters from rural schools, parochial schools, and the Dickinson Public Schools. The ethnic background, educational background and the academic strengths of the ninth graders are far more

diverse than most schools who have as their "feeder schools" the system's elementary schools.

Many children enter grade nine with strong mathematical backgrounds; others need much help in basic mathematics.

There has been serious concern about the progress demonstrated by children who have been taught general mathematics in the conventional manner.

In a survey made of Dickinson High School Class of 1965, ninth graders of 1962, the record revealed the following data:

Total enrolled ninth grade students
Dickinson High School, 1962 111

Total enrolled in general mathematics
Dickinson High School, 1962 36

Of the 36 general mathematics:

Drop-outs.	4*
Transferred.	5*
Enrolled in advance courses. . .	6
Enrolled in bookkeeping.	7
General math only, graduated . .	14*

* Group which has general math as terminal mathematics 23

Indications of preliminary data are even more convincing of later classes that the problem is becoming more acute. It is reasonable to suspect that this trend will be with us until the youngsters who are receiving a firmer mathematics foundation do ultimately reach the ninth grade.

No doubt the problem will rectify itself. However, facts are facts, and they indicate that presently from 25 to 40 percent of the Dickinson High School youngsters leave school unprepared to face life in a mathematical sense.

Proficiency studies of elementary grade Dickinson Public School children indicate very excellent progress.

RATIONALE

Dickinson Public School's basal philosophy is steeped in the contention that all normal children can learn basic mathematics; that indeed they must learn basic mathematics if they are to live normal lives in this complex and industrial country.

The school philosophy is described in the next few pages.

Philosophy for Teaching Mathematics, Dickinson Public Schools, 1966

The world of today demands more mathematical knowledge on the part of more people than ever before, and the world will make still greater demands.

Because understanding the role of mathematics in our society is prerequisite for intelligent citizenship, persons concerned with curricular offerings must accept the responsibility for continually evaluating and improving the program in mathematics to be certain it is adequate and appropriate for contemporary education.

DICKINSON PUBLIC SCHOOL CONCEPTS

The general math course in high school is intended as a remedial course in mathematics. It develops understanding and lays a solid foundation for future mathematics. It also renews arithmetic understanding and skills that are needed in our more advanced math courses.

Concepts	Model - Activity
Whole numbers	Reading large numbers, rounding off whole numbers, addition of whole numbers, subtraction of whole numbers, multiplication of whole numbers, division of whole numbers, averages.
Common fractions	Reducing fractions to lowest terms, changing fractions, improper fractions, changing mixed numbers to simplest form, changing a fraction to higher terms, lowest common denominator, equivalent fractions, addition of fractions, subtraction of fractions and mixed numbers, comparing fractions, changing mixed numbers to improper fractions, multiplication of fractions and mixed numbers, division of fractions and mixed numbers, finding what part one number is of another, finding a number when a fractional part of it is known.
Decimal fractions	Reading and writing decimals, rounding off, addition of, subtraction of, multiplication of, division of, multiplying and dividing 10, 100, 1000. Changing fractions to decimals, and decimals to fractions. Short methods in multiplication and division.
Percents	The meaning of percents, percent to decimals, changing decimals to percent, changing percents to common fractions, changing common fractions to common per cents. Finding a percent of a number, finding what percent one number is of

	another, finding a number when a percent of it is known.
Squares and square roots	Squaring a number, square root.
Measurement	Basic units of length, lines, scale, perimeter, circumference, indirect measurement, bar and line graphs, area of geometric figures, volume of geometric figures, liquid measure, dry measure, measure of weight, income, budget expenses, interest, clock. Relationship of volume, capacity, and weight units of measure, compound numbers of two or more denominators, metric system in measure, speed, angles and arcs, practical application of angles and arcs, angles in navigation, constructions of geometric figures, bisecting a line and angle, and parallel lines, circle graphs, the use of the mill in artillery and gunnery, longitude and latitude.
Everyday problems	Income, take home pay, thrift, household and family car expenses, home making, interest, installment buying, insurance, taxes, owning a house, stocks and bonds, commission, discount, progit and loss, general business and business forms, deposit slip, check, invoice, promissory note, industrial applications, lumber, construction.
The formula	The language of the formula, literal representation, meaning of signs of operation, algebraic expressions, and writing formulas. Evaluation, algebraic expressions, solving for any missing value in a formula.

SOLUTIONS

Why were several approaches sought in remedy for the serious mathematical deficiency problem facing many of our youngsters?

Conventional textbook, lock-step, teacher oriented general mathematics has been taught for many years. The problem hasn't

been solved satisfactorily.

Shouldn't other approaches be sought?

Remediation for children with individual problems very often required that a teacher have a one-to-one relationship with the child. Small group instruction may suffice when common problems are prevalent. Remediation teaching using a thirty to one ratio relationship just doesn't work with a conventional textbook teaching approach.

Could a single individual approach be found which would allow each child to overcome his deficiencies--one that would still allow a teacher/child ratio of 1 to 30. Programmed Basic Mathematics by Encyclopaedia Britannica Press made such claims.

Dickinson School officials thought that there was much to be gained by trying to solve the problem.

IMPLEMENTATION

Conventional textbook-teacher-centered approach was used for two sections of general mathematics. Programmed learning was used for one section. There was a total of 62 students; 19 in programmed material, 22 in one conventional general math section, and 21 in the other conventional math section.

TEACHER ORIENTATION

Questions about the program

Basic Mathematics by Daniel Bobrow, Encyclopaedia Britannica was used in teaching twenty-eight youngsters at Dickinson High School

during the school year of 1966-67.

1. What is a program?

A program is a written presentation of a body of subject matter. It may present as little as a single idea, fact, concept, or technique and as much as the content of a full year's course of study.

2. How does a program differ from a "regular textbook"?

It differs in at least three major ways.

(a). It provides not only the "subject matter content" of a textbook, but also the repetition of this content, the comparison and contrast of this content with material already learned, and the periodic review of this content which are the necessary ingredients of learning.

(b). It provides for constant student interaction with the material. Hence, the student becomes an active participant in, rather than a casual observer of, the educational process. Textbooks provide only periodic interaction with the material, through exercises at the end of sections or chapters. Programs require constant interaction by questions while the student is learning rather than after the learning has (or has not!) taken place.

(c). This frequent questioning, together with providing him the opportunity to "check as he goes", gives

the student both the motivation of knowing he is progressing well, when he is and the opportunity to stop--think--and change direction before large blocks of misinformation are "learned", when incorrect responses indicate that such change of direction is necessary!

3. Programs look like workbooks; aren't they just "fancy" workbooks?

Workbooks merely provide drill which is intended to "fix" ideas which were acquired elsewhere. Programs, on the other hand, present these ideas as themselves, together with more interesting methods of fixing these ideas than just drill along.

4. Much has been said about the contribution of psychological research to the field of programmed instructional materials. What basic ideas from this research have influenced program writing?

The psychological principles which are involved in the theory and practice of program writing are these:

(a). Learners should be regular participants in the process of learning.

(b). This participation should consist of the answering of questions which are difficult enough to illicit thought but not so difficult that overly frequent incorrect answers occur. Though there may be validity in the adage "we learn by our mistakes"

research has shown that we learn better by our correct answers. The negative effect of frequent criticism and correction can destroy the motivation of even the most dedicated student! Though questions must be sufficiently challenging to force progress they should not be so challenging that true progress, through correctly given answers, is denied to the student. "A pat on the head" for a correct answer is better motivation for progress than "a rap on the knuckles".

(c). Learning progresses most efficiently if the learner constantly "knows how he's doing". This adds security to the student who is progressing well. It also stops quickly the student who is about to "get on the wrong track".

5. How is the material in a program organized?

The overall organization differs somewhat from program to program. However, the basic structural unit is the same for all programs. This unit is the frame--a name introduced in the early "teaching machine" days. A frame may vary in length from one sentence to an entire paragraph. Its length is determined by the particular content being presented. The essential characteristics of a frame are that it presents a small, but meaningful, "piece" of a concept or technique and (usually) provides the opportunity for the student to interact one or more times with this content

through answering questions or supplying words to complete sentences, and provides the student with the opportunity to check his answers.

In many programs, these frames are grouped into sections, the sections into chapters and the chapters into units just as is done in an ordinary textbook. Some include exercise lists, review exercises, summaries, progress tests etc., again as in ordinary textbooks.

6. What are some of the technical terms used to describe programmed materials?

There are many such terms. Among the most common are "branching", "bridging" "constructed response", and "linear". These, and many more refer to the method by which a student makes the required responses to a given frame and to the way in which he proceeds through the program.

(a). Constructed response frames are frames in which the student is required to "construct" a response by giving a word, group or words, sentence or group of sentences as his response. The most common alternative to this is the multiple choice response frame in which the student need only select one from a list of several possible responses.

(b). Branching refers to a program so constructed that at certain points students are asked certain important (usually multiple choice) questions and are directed to various points in the program according to which

possible response they choose. The student selecting the correct response proceeds to new material; the student selecting an incorrect response is directed to the proper remedial material to explain his error and to help him correct it. An alternative to "branching" programs are "linear" programs in which all students proceed "straight through" (in a linear manner) all frames. Thus, all students study exactly the same material. Another alternative to a "branching" program is a "bridging" program in which progress through the program is "straight ahead" for all students (as with a "linear" program); however, at certain "checkpoints" progress tests are given. Students who have learned proceed to new material; students who need additional explanation and drill on the concept being studied are provided with this before going on.

7. Which of the methods of organization, "branching", "linear" or "bridging" are best?

Each method is particularly applicable to certain types of subject matter and to certain types of students. In general, a linear or bridging program is easier to use than a branching program. Also, in a body of subject matter which is logically organized "from start to finish", the "side-trips" provided by a branching program can break the logical flow of the content, hence

destroying the learner's momentum. However, when critical thought, the consideration of several almost equally good answers and the discussion of several means of progressing from one point to another are an essential part of the content to be learned, a branching program can be useful. The best program is the one so constructed that it uses whichever of these (and other) methods of organization best fits the material to be taught and the student who is to learn.

8. Is the construction of a program tied to any particular theory of learning?

It is certainly tied to whatever theory of learning its author adhers to! Of course, this can also be said of the learning situation provided in any class; the teacher teaches so that students will learn. How he (or she) teaches depends upon how he (or she) believes that students learn. There are programs which are written to employ a "tell, then do" (reconstruction) method, not unlike the traditional lecture--example classroom method. There are also programs which are written to employ the "discovery" (inductive-analogical) method which is becoming increasingly popular as a classroom method today. There are other programs which incorporate a wide variety of other methods of presentation, each based upon the author's belief concerning how learning takes place.

9. Can programs do more than just provide a palatable substitute for rote memorization? Can they be used to develop concepts?

It has been claimed by some critics of programmed instructional materials that they cannot be used to develop "big ideas", to present concepts. The claim is probably made because their experience with programs has been limited to those specifically designed to replace rote memorization by a meaningful and interesting learning experience. Many programs are so designed; parts of most programs are so designed and the fact that such programs do what they are designed to do is a strong point for programmed materials.

However, the fact that a program designed to make possible a certain type of learning does what it is designed to do in no way implies that programs can only induce this type of learning! Programs designed to induce concept formation can induce concept formation; programs designed to facilitate critical thought can facilitate critical thought, etc. A multiplication table in a textbook may be placed there to be memorized. Although this may be the case, no one would claim that only "learning by rote" can be induced by the use of any part of this textbook! A talented author creates a program which is a flexible teaching device. It can induce whatever type of learning the author intends to induce. (See the comments about it in #6 in relation to this last remark)

10. Since the role of the program author is so important, what type of person should write programs?

A noted author of programmed materials said, "No one should

write a program who could not write a fine textbook. However not everyone who can write a good textbook can write a good program."

Clearly, there are four major talents necessary for the construction of a good program:

(1). Knowledge of the psychological principles underlying programmed materials (See question 2 above).

(2). Through knowledge of the content to be contained in the program.

(3). Ability to communicate ideas to the intended audience.

(4). Considerable ability as a creative writer.

Sometimes, all of these talents exist in a single author. More often, in order to obtain all of these talents it is necessary to form a writing team with various individuals contributing their specific talents.

11. How can an author or the authors of a program be sure that they have attained the goals with the program which they set out to attain?

A program is written to induce certain learning in a certain type of audience. The only way to determine if the author's goals have been achieved is through extensive texting of the program. This testing is done in cooperating schools, in regular classroom situations with regular classroom teachers. Results of this testing are collected, analyzed, and evaluated. On the basis of these results the program may be "accepted as is", revised to strengthen weak points, or entirely rejected. Great

care is taken to see that if a program goes badly the test is terminated before any damage is done to the educational progress of the test subjects. Whenever inadequate learning is being induced the teacher can withdraw his class immediately from the test structure. (In three years of testing mathematics programs, Encyclopaedia Britannica Press has had few (if any) occasions of the withdrawal of a class from the test of a program.)

Three points are covered in the testing program.

(1). Did the test subjects learn through the use of the program? This is determined by the comparison of a student's performance on a test which is administered twice; once prior to study of the program, again upon completion of the program.

(2). Did the students achieve external goals set by the school or the educational community? This is determined by scores on nationally normed examinations, where these exist, by departmental tests, where these exist, or by tests developed with the help of "outside experts", where neither of the above exist.

(3). Did the teachers involved approve of the program? Teacher comments are solicited by the authors and prove to be of great value in determining how a program can be improved.

Questions about the Use of Programmed Materials

I. No teacher?

Aren't programs designed so that students can learn from them without the aid of a teacher?

Yes; and so (hopefully!) are textbooks! However, this is certainly not to say that the interaction of a teacher and a program cannot provide a learning experience for students which is superior to that provided by either a teacher or a program alone! A good teacher can transmit ideas without the use of a program, a textbook, or for that matter, a piece of chalk! However, no one would seriously argue that a teacher's effectiveness is not enhanced by the use of some or all of these (and other) materials. Likewise, the fact that the program is designed so that it can do a job alone in no way implies that it cannot be used to do an impressively more effective job when used in conjunction with other educational "devices" including, of course, that most effective "human teaching machine", the teacher!

II. Lockstep

In many discussions of programmed materials the term "lockstepping" arises. How is this term used in reference to education?

The term "lockstep" has two meanings when applied to education. One meaning applies to an administrative structure; the other applies to the intellectual progress of an individual student.

"Administrative lockstep" refers to the organization of most schools in which students are graded on performance at six or nine week intervals and move from one course to another at semester or

yearly intervals. Thus, a course such as Algebra I is defined to be what is studied for (say) 180 days, 50 minutes per day, with progress grades being given periodically during this time. The alternative to this is the "individual progress" school in which Algebra I is defined to be a certain amount of content (contract). Whenever a student satisfactorily masters this content, he goes on to the next course; perhaps in as little time as 90 to 100 days perhaps in as long a time as 250 or 300 days. Promotion periodically spaced by time but periodically spaced by progress through the course.

Clearly, departure from the "administrative lockstep" requires an administrative reorganization of all or part of a school system. Dickinson school systems are effecting this departure, at least in some subject matter areas.

The "intellectural lockstepping" of the individual child is partly a result of "administrative lockstepping" and partly a result of the traditional method of presenting new ideas to children. "Intellectual lockstepping" refers to the fact that new ideas are commonly presented to all students in exactly the same length of time, although we are quite cognizant of the fact that different students need different lengths of time to assimilate these ideas! Many have criticized this as a serious weakness in the educational process!

"Intellectural lockstepping" arises because, in general, new ideas are acquired by the student only through the presentation of these ideas by the teacher. Anyone who has taught knows

that students obtain a minimum amount of new information from textbooks. Tests are used to review, to "look up" and for lists of questions or exercises. However, the almost exclusive source of new information is the teacher. Also, the learning situations (except for routine drill) in which this information is to be "fixed" in the mind of the student are "teacher centered." This means, of course, that the time for this presentation and learning is the same for all students--hence, intellectual lockstepping, resulting in frustratikn and failure for competent, though slower, students and boredom for the brightest students!

III. Lockstep Broken

What is the connection between programmed materials and breaking these "lockstep" situations?

As we have already commented, the "administrative lockstep" can only be broken by a change in administrative policy (and also, in some instances, changes in state law and college entrance requirements). However, when this is done, it becomes obvious that "individuál progress" means "individual instruction!" Thus, self-study materials, in programmed or other form, become necessary. In such a situation, the teacher becomes "teacher to each" instead of "lecturer to all"--a decided change in role for most teachers.

The major motivation for administrative reorganization, where it has taken place, is to remove the admittedly serious effects of "intellectural lockstepping". A great contribution of programmed materials is that they can be used to break the

intellectual lockstep without, or until, administrative re-organization, which provides an individual progress school.

Obviously, such an extravagant claim required justification! To provide this we need only look at the learning situations which can be provided with and without programmed materials.

A. Without Programmed Materials

(1). Teacher presentation of new material (usually with an admonition to "read the test"!).

(2). Teacher centered discussion and example working

(3). Assigned question answering (drill) for the remainder of class time and for homework!

Without programmed materials, (1) and (2) above constitute the entire opportunity for the student to understand and assimilate new material and (1) and (2) are presented for the same time to all students!

B. With Programmed Materials

(1). Teacher presentation of new material, succinctly given; often only in the form of an "overview"

(2). Work on the program, in class and, for slower students, at home. Teacher assistance to individual students as necessary.

Both (1) and (2) in this approach involve the presentation of new material with (3) providing for individual rates of assimilation. The intellectural lock-step is broken!

IV. Optional methods of teaching

In what way or ways can programmed materials for a course be implemented? What is the teacher's role in each such implementation?

Let us outline in detail three possible implementations

1. Individual progress class

   a. Each student works through the program at his own individual rate, working only in class or in class and for an assigned period of time outside of class. No attempt is made to keep various students together in the program.

   b. Testing procedure

      Tests are administered at pre-assigned points in the program to each student as he reaches these test points.

   c. Grading procedure

      Ideally, grades are given at certain points of the program, not periodically by time. When six week grades are required these can be assigned either in terms of two grades-a quantity grade and a quality grade-or a single grade is assigned which is some combination of the quantity and quality of the student's work.

   d. Promotion procedure

      Ideally, completion of the program with a prescribed mastery of content leads to immediate promotion to the next course. Where year by year promotion is the rule, provision is made for enrichment work for fast students and extra work time for slow students.

Enrichment work can be done periodically or used to fill out the year after completion of the program. Extra work time can be acquired either through homework and free period assignments or by giving an incomplete at the end of the year and making provision for program completion during the summer.

e. Teacher Role

The teacher's work is more with individual students or small groups of students than with the entire class, although class review sessions are useful. Discussion of test results with each student is recommended. Teacher centered enrichment activities for more able students and teacher aid to speed the progress of slower students are also parts of the teacher role. Some teacher-centered oral or blackboard work each day (perhaps for five to ten minutes) has proved useful in providing an important variety to the learning situation.

f. Course Content

The content of the program serves as the basic course content for all students. Hence, much care must be taken to select a program which fits the course objectives of the school. However, much variation from this basic content can be provided by the teacher by:

(1). Changes of emphasis brought about by supplementary

assignments to stress points considered of maximum importance.

(2) Introduction of material, presented in a traditional manner, which is not in the program.

(3). Provision of enrichment activities for more able students

(4) Introduction of new ideas or additional stress on ideas covered in the program through individual or small group discussion.

g. Points to consider regarding this type of implementation

(1) Most educators consider provision for individual rates of student progress an important educational advantage

(2). An individual progress implementation of programmed instructional materials is ideally suited to an individual progress school. However, such an implementation is possible within a group progress school. In a group progress school certain problems of grading and promotion do arise, but they are far from insolvable! Comments on how these problems are being solved are included under the appropriate heading above (testing procedure, grading procedure etc.)

(3) The teacher's role in an individual progress class is considerably different from the teacher's role in a traditionally organized class.

Adjustment to this new role is easy and richly rewarding for some teachers, difficult for others.

(4) While supplementation of the content of the program is possible (and, at least for the most able students, necessary) it is not easy to depart as far from the content of the program as many teachers do from textbooks. This has the advantage of providing more standardized instruction; the disadvantage of some possible teacher dissatisfaction.

2. "Block of Time": Class

a. Assignment procedure

Material is assigned on a "block" basis. For example, perhaps 20 days for Chapter 1. Students who fall behind a rate which will allow them to reach this 20 day goal are required to work an extra amount of time outside of class. Enrichment work may be necessary for students who proceed quite rapidly. Very slow students may find the amount of necessary outside work too great! They may have to omit some parts or take tests without completing all of the material.

b. Testing procedure

All students complete a block of material at the same time and are "group tested" as has always been done.

c. Grading procedure

Since all students are "together by blocks" grading is done as in a traditionally organized class. No difference of quantity of work exists so grading is (as traditionally) on a quality basis.

d. Promotion procedure

Same as in a traditionally organized class; only quality work need be considered.

e. Teacher role

In such a class, the teacher's role is not unlike that in a traditionally conducted class except that more variety of presentation is possible. The teacher can do all of the "old" things, but does not have to do them all! For example, the following presents a possible class conduct outline:

(1) Teacher gives an overview of a new idea

(2) Students work on programmed material; teacher works with individuals.

(3). Teacher discusses with all students material being studied, as he (or she) desires; part of each day or for a full day once or twice a week.

(4) Teacher introduces ideas or techniques to supplement the program as he desires.

(5) Teacher conducts oral review sessions prior to (group) tests.

f. Course Content

The teacher asserts considerable control of course content by:

(1) Determining the "blocking" and the time to be spent on each block.

(2) Supplementing the program with additional topics or additional depth on included topics (possible because the students are "close together" in the program).

g. Points to consider regarding this type of implementation

(1) This procedure allows for the implementation of programmed materials with no appreciable administerative,testing, or grading changes and with no radical change in teacher role. Although it adjusts programmed materials to administrative group progress procedures, it does this without imposing the educationally harmful intellectual lockstep for, although students are kept together by "blocks", they do meet and assimilate new ideas at their own rate, through varying amounts of time spent working on the program within a block of days in which a certain amount of material is covered. (although John and Jim both do Chapter 1 in 20 days, John may use only 800 minutes of learning time while Jim uses 2000 minutes! Without programmed instruction materials

the actual "learning time" (teacher-centered) is the same for both!)

3. A combination of I and II

This consists of a type 2 implementation for the great part of a class (perhaps 90%) with a "type 1" implementation for the few very strong and very weak students. This proceeds as follows:

(1) Begin with type 2 for all. Recognize as soon as possible if there are strong students who are being over extended by the "blocking" which best fits the class as a whole.

(2) If such students exist treat them as separate groups with a time blocking appropriate to them.

(3) For the most able students, provide (group) enrichment activities, either through the year or upon early completion of the program. For the weaker students, provide either additional supervised periods of work or the opportunity to complete the program in an extended length of school time (a summer session, summer self-study, or an extra semester).

V. Which is the best one?

This, of course, depends upon the particular school system--its administrative philosophy and structure and upon the degree of the commitment of its teachers to this philosophy.

In an individual progress school, clearly the implementation

procedure labeled 1.provides a use of programmed materials which is completely harmonious with the administrative structure of the school and which allows the programmed materials to make their maximum contribution to the education of the students.

In schools which maintain the group progress administrative structure but desire to achieve the advantages of individual progress in some classes or subject matter areas, a type I implementation is also profitable. However, in such schools both administrators and teachers must be aware that certain new administrative procedures may be necessary and should plan in advance for these procedural changes (See sections on testing, grading and promotion under the description of implementation I.)

In a sense, implementation procedure 2 represents the other extreme from the individual progress implementation. It is a procedure which "bends" programmed instruction as far as possible to fit existing school situations while still maintaining the essential gain provided by programmed materials--the breaking of the "intellectual lockstep"--the "get it now or never" characteristic of the uniform time presentation of new material to all students. A school with no major commitment to individual progress but with an honest desire to provide improved education for all students will find this a profitable and easily administered implementation.

As has been stated, implementation 3 is a compromise combination of 1 and 2 requiring less commitment to individual progress than 1, more than 2.

For a school system which has not used programmed materials

and which has not tried other forms of individualized instruction and which is not particularly committed to an individual progress procedure, clearly implementation 2 provides a method of attaining genuinely improved education for its students through the use of programmed materials with a minimum change in existing administrative and instructional practices. Hopefully, a type 2 implementation will be for many schools, an easily taken first step which may lead to type 3 or (eventually) to type 1 implementations as the advantages of individual progress and individualized instruction become clear. However, if no such progression takes place, a type 2 implementation will continue to provide improved education for all students!

Part III A sample Program

Since a basic premise of the field of programmed instructional materials is that questions are best answered, learning is most greatly aided by doing, no discussion of programmed materials would be complete without an example of such materials. Such an example, designed to teach an interesting fact about addition of whole numbers, is included. For those familiar with programs this will provide an interesting experience in learning from these materials. For those who do not have this familiarity, this will provide an illustrative example of some of the terms and ideas of Part 1 of this discussion. The rules are simple:

(1) Cover the column on the right with a sheet of paper

(2) Read each numbered frame carefully; decide upon the correct response and fill the black.

(3) Pull down the paper to check your response with the correct one.

(4) Go on to the next numbered frame.

Should We Use Programs in Our Schools

New questions that cluster around administrative problems and teacher roles will also need attention. For example:

I. Administrative changes?

1. What impact will a program have upon scheduling and the existent curriculum?
2. What training of teachers is required before a program is used?
3. What are the costs of acquiring a program, training teachers to use it, and evaluating it?
4. Before initiating the use of a program, must the purposes, procedures, and methods of evaluation be fully outlined and understood by all involved (staff, children and parents)?
5. What are the logistics (building, space, special needs, etc.) that must be considered?
6. What will be the effect of the program on the current procedures of reporting pupil acheivement to pupils, parents, and other institutions?

II. Changes in the teacher role?

1. What are the effects of the program on teacher procedures?
2. How can the teacher reinforce the program and the program

reinforce the teacher?

3. What effect will the self-pacing quality of programmed instruction have upon the teacher's work in the classroom?
4. How will the teacher evaluate the pupil's work?
5. What should be the responsibility of the teacher in outlining long-range and short-range objectives for the class?

The answers to such questions must be developed locally. This handbook underscores the important questions and ways of dealing with them.

1. Teaching with programs, Knowing the Subject Matter

There is no substitute for the teacher working through the program as if he were a student, making notes of the characteristics of the program, the design and the organization. This firsthand experience with the program will make the summary and suggestions in a teachers manual much more meaningful. This direct knowledge of the style of presentation will enable the teacher to determine whether the frames of the program are presented in a clear manner enabling complete understanding by the different learners in his class. This, combined with his knowledge of his students, tells him where he must provide different initial instruction; it alerts him to likely differences in later student progress. This is one of the surest ways that the teacher can enter cooperatively into the leadership of the learning process.

Not only will the teacher know what the program teaches, he will know what it does not teach. He will also appreciate that it teaches a way of learning, that it is structured to force a student

interaction with the program.

Study the teachers manual and data on student performance. A thorough familiarity with the teachers manual or handbook which accompanies the program is also part of knowing the subject; the teachers handbook helps explain how the program was designed, at what behaviors it is aimed, how it may be subdivided, and what kind of performance may be expected from the teacher's kind of learners.

KNOWING THE STUDENT

It is axiomatic that the best teachers know their students well. Sometimes this is general knowledge--an uncanny insight into the typical interests or characteristic learning difficulties of students at different levels and stages of learning a subject. Sometimes this is very specific knowledge about a specific student. Ideally the teacher should have both general and specific knowledge of the students in his class. For example, what preparation have the students had for a particular program? How do they differ in their readiness for independent study? Which ones will follow instructions? Which ones treat rules as something to be broken? Which ones will speed? Which ones move slowly? Which students have styles of learning or set patterns of study that are too much at variance with the structuring in the program under consideration?

2. Preparing the Student to Learn with Programmed Materials

One of the oldest slogans in education states that enthusiasm

is caught, not taught. It is hard to overestimate the influence of the teacher's enthusiasm for learning. The model of the teacher and the attitude of the teacher toward individual effort and success with programmed materials are in fact extremely important elements in the preparation of the students for any instruction--especially self-instruction.

"Preparation of the student for learning," developing learner readiness," "structuring," and "cueing" are so classic in education that there is no point in belaboring this obvious principle. Especially with programmed learning, which may introduce novelty in method and sharp definition of what is to be learned, the learner may need special orientation.

Explain the uniqueness of programmed materials. The student must not be permitted to misconstrue the function of the program. It must be clearly understood that the program is intended to instruct--not to examine! If this point can be communicated, it will go a long way in reducing the concern about cheating.

There will be--and should be--great variation in the time required by students to complete a part or all of the program. The important thing is that the student move along with reasonable speed and success at each point. This is quite different from standardized test results, where the test is designed to produce a range from very low to very high. The student must realize that he is on his own with a new instrument for teaching, not testing.

Determine if the students are ready for the program. Unless it meets the interest and needs of the student, the program itself

is ineffective. The insightful teacher estimates interest, need, and other conditions of readiness by general observation of the level at which the pupils are functioning in the class. Of special help in appraising the specific backgrounds of students are the pretests provided with many programs. In addition, the teacher's inspection of the program itself may have revealed the need for prerequisite reading skills, nomenclature, background, and abilities which the students do not have. The teacher may have to help the students develop such prerequisite abilities--or decide against the use of the program at this time.

Give attention to the setting for learning, wherever it may be. Because programmed materials are so often used outside the classroom--in study halls, in offices, or at home--it is especially important to remember that knowing the student may involve knowing something of the additional motivation and educational support that he receives in home and out-of-class environments. Frequently, the teacher who is so strongly praised for knowing the student is a teacher who has taken those extra steps of knowing the out-of-class resources for the student's learning and has joined forces with these resources.

Watch for symptoms of learning difficulties. Once it is determined that the program does meet the needs of the students, the teacher will look for ways to stimulate and to motivate. Even when the students are working through the program, the teacher will be alert to symptoms of fatigue, boredom, excessive erasures and corrections, unusual patterns in test scores, and student initiative

in program-stimulated activities. Such behaviors provide information about the learner's progress and interaction with the program. It is the teacher's function to assess needs, interest, and progress and to make educational decisions that help the student work at the level of the program appropriate for him.

The student should understand that he may make a few errors' but if he makes many errors, the program is probably unsuited to him. He will need to understand that he may have to be more self-directing in his instruction, and he may need the encouragement of check-off charts and routine schedules to get started.

In short the use of programs in classes will require some changes in habits and attitudes of students toward instructional materials. The teacher will be cognizant of this fact. The students should be helped to understand the different format of programmed materials. He needs to know if he must write the exact or an approximate response. He will want to know the basis of appraisals or marks that will evaluate his work, and probably what happens and to what he moves when the program is finished. The student may look upon programmed instruction as new and unusual, and for reasons of his own unfamiliarity or his apprehension over the school's acceptance of his programmed learning, he may occasionally revert to older procedures. This is a reasonable request which the teacher within his resources, just as he accepts other suggestions for enrichment and supplemental activities. As would be the case with any other innovation, the teacher or school would want to consider how it should inform the parents.

Strive for home-school cooperation. Educators are in general agreement that the educational process is actually a cooperation. Too often the decision making is unilareral, with either the home or the school merely being given the opportunity to acquiesce.

3. Ways of using programmed materials

Enrichment in the school offerings. For many students the conventional school offerings are adequate neither in depth nor breadth. The individual nature of programmed materials makes them ideally suited for providing individual enrichment according to such personal needs and interests. Often such students already have good individual study habits, and the problem is not so much one of supervising them (in their programmed instruction) as in finding appropriate materials to enrich their schooling.

Review. Some teachers have been using programs for systematic reviews for their students. This, too, can take two patterns: (a) review used as prerequisite at the beginning of instruction as a kind of reconditioning to bring old learnings into active use, and (b) review used as a summary after instruction by more conventional methods.

Remedial instruction. For a student who has been unsuccessful with conventional instruction, programs may prove helpful because of their small steps and immediate reinforcement. The unsuccessful student who is still anxious to learn is, of course, very different from the student who failed because he either did not want to learn or did not try; and his approach to a program would be very different.

The former should find programmed instruction refreshingly rewarding.

For the slow-learning student or the student who has not experienced success, programmed instruction is no panacea nor can it perform miracles. But many a student who has never attained any success academically may find that programmed learning can give him a new experience. For the student who has found that his efforts are always topped by a faster, more aggressive, more verbal student and for the student who expects such little chance of success that he has quit trying, the self-pacing and the success in small sequential steps offer a different stimulus. He need not be embarrassed. His failures are made in private. His delays do not delay the class.

The slow-learning student who is strongly motivated is not likely to take the initiative in searching out self-directed, self-tutoring materials; but he has his motivation going for him once the teacher helps in the identification of study materials. Usually there are reading problems that need to be considered. The student who has experienced only failure is not so easily motivated and may even be suspicious of one more effort to help him.

Independent study, self-instruction, the homebound student, and the motivated student without a teacher. Programs have been carefully prepared so that to a large extent they can stand alone without a teacher or a school. Much of the popular interest in programs has been directed to this characteristic which enables learners to be "more on their own."

The ungraded nature of programmed materials and the flexibility provided by modular organization facilitate its multiple uses. What may be appropriate acceleration for one student may be appropriate remedial work for another. Many programs carry no grade-level labels: the professional educator can prescribe as needed.

Instructional research. The predictable instructional sequences, the specificity of teaching strategies and student behaviors, the provisions for records of behaviors--these are ideally suited to the replication of research studies. Thus programs have stimulated considerable interest in research and instructional technology.

4. Appraisal of students

Programmed instruction is designed to instruct--not to categorize or grade students.

Pretests and end tests. Although the programs themselves are not tests, there are tests provided with most programs. Sometimes the pretest and end test are identical. The teachers manual or handbook usually provides some basis for appraising such results. Some programs also provide unit tests.

Marking. Ideally the student should aim at mastery of the program and be gratified when he obtains this goal. For the out-of-school learner and possibly for the student who is branching into enrichment, this is usually adequate. But the conventional gradings and markings of our school system have become so ingrained that students and teachers may feel lost without such labelings.

A plea is made here to avoid spoiling the instructional emphasis of programs with artificial or arbitrary markings that may induce cheating.

Credit. Giving credit for work completed, like giving marks, is part of the administrative machinery of school systems and subject to the policy of the respective school. It is possible but unlikely that a school would give credit for merely completing the program. The program itself might be combined with a system of proficiency examinations, and this combination--as is common practice with correspondence courses--might be creditable by the school.

Helping the student as he progresses. Quite different from the appraisal for classification purposes is the ongoing appraisal that is aimed at helping the student obtain better results from his learning efforts. The student should be encouraged to make his difficulties known to the teacher, after he has put forth an honest effort, for by noting such difficulties the teacher may reappraise the appropriateness of the program. In line manner the fast-moving student's record is examined by the teacher so as to determine whether the student should touch every step in the sequence or whether the unit pretests indicate that he should be accelerated forward.

Students should be encouraged to keep progress records. Such a record might consist of a weekly summary or a daily log indicating the following: time working with program; started with frame number, stopped at frame number; frames I didn't understand; ratio of number of errors to number of frames completed; scores on pretest, unit

tests, etc; comments.

The teacher will also be using the individual records as guides in making meaningful groupings of students for special instruction, introduction of new material, or reteaching. In most classes the students readily accept the fact that students work differently, at different levels and speeds; and where the climate for learning is an open, cooperatively supportive one, the students make their own entries on a master chart of progress and problems with programs.

III. Deciding where to use Programmed Instruction

Some of the previously mentioned decisions, such as the decision to make the program the initial and main part of instruction for the class, would of course determine whether the program would be used in the classroom itself, in a study room, or as homework.

Even though individualization is such an outstanding characteristic of programmed learning, the teacher will want to capitalize on the stimulation that derives from good social settings and interpersonal relations. When a class has developed a climate in which there is enthusiasm for learning, that classroom would be setting in which the programmed materials would gain from the social stimuli for learning. There is another side to this coin: If the study hall is a place where "playing around" is popular and efficient study is the exception, programmed materials will perform no miracles.

The same might be said for homework settings. Some homes are supportive of study; others are not. In some schools every student

expects homework and does it. In others, homework is viewed as the responsibility of the teacher and is given attention according to the threats and power of the respective teacher.

Thus the decision on where to center the work will be guided by knowledge of local conditions which are conducive to self-tutoring for the individual students. Certainly the initial efforts with the program might best be done in the classroom under the supervision of the teacher.

Sometimes the decision as to where the students will work on programs will be influenced by such logistic matters as space, school schedules, and the number of programs available for sharing. Problems of accession, storage, and administration are very real concerns in the use of any instructional materials, and the teacher must not treat these lightly.

Other administrative decisions will have to be made about the schedules and the location for student use of programmed materials. The data from field tests, as supplied by the developers of the program, and the teacher's tryout with a few select students will give some basis for estimating how long it will take for students to finish the program. If all students are to be finished at about the same time, then there will have to be considerable difference in starting times.

Some attention must also be paid to the handling of programs, especially if there are looseleaf, or in teaching machines, or in some other way must be shared. In many schools the programs will be school property to be used by several students; there may be a

financial dictate against writing in the program itself. In all these matters of handling and managing programs, the students can be guided into being their own caretakers. If this is not the case, the busy work of program management is more than the teacher has bargained for, and teachers feel that they are working for the program. Obviously when this happens there is some evidence that the program is not feasible for the school situation.

The purpose of this handbook stops short of asking teachers to become highly sophisticated about programmed instruction and its new terminology and developmental techniques. The aim is to help teachers to be effective users of programs. Reading about programming, for example, is helpful in selecting a program, but it is not so important as studying the program itself and the publisher's manuals or data which come with it.

EVALUATIONS AND RECOMMENDATIONS

Evaluation and recommendations are based on professional observation, teacher-made sampling devices and the use of the Iowa Test of Educational Development. The ITED Test was administered in September of 1966 and again in May of 1967.

Findings were not conclusive; further refinement of evaluation is needed.

Evaluation did indicate the following:

1. Questions sampling basic knowledge as related to school objectives indicated that youngsters who had participated in the programmed material scored higher than those enrolled in conventional general mathematics. (Exceptions are listed in the next two items)

2. Questions dealing with fractions were most consistantly answered correctly by students in the conventional mathematics program.

3. Two students with the most overall growth in mathematics were taught by conventional methods.

4. Questions related to course objectives but written in sophisticated mathematical vocabularies were most often correctly answered by students in programmed basic mathematics.

5. Questions with a less sophisticated vocabulary were answered more times correctly than the questions of a sophisticated vocabulary but not as well as the students in the programmed basic mathematics answered the questions.

6. Both the controlled groups and the uncontrolled groups showed evidence of negative attitude. (Natural)

7. All youngsters in the uncontrolled groups will finish the course whether they complete the stated objectives of the course or not. Several will fail the course.

8. Some of the youngsters in the controlled groups (Temac) will not complete the course this year, some have completed the course and are enrolled in Modern Algebra, and some will complete the course in the scheduled time.

Recommendations for Remedial Mathematics Instruction

1. Programmed instructions provides for individualized instruction however administrators and teachers can "lock-step"flexibility out of existance. Provisions must be carefully ascertained to prevent such happenings.

2. Remediation instruction required sophisticated instruction. Over-loading classes will decrease the instructional efficiency. When conventional teaching methods are used, classes should not be filled to more than fifteen students per class. With programmed materials, instruction begins to suffer after twenty-five students limits are reached. Of course, extremely talented teachers will disprove these "magic figures", however, let us not forget that "Education has Sinned" for many years for these youngsters. This is a "last chance" in mathematics for some of these youth. Time and effort should not be "mass-fed" as expedient measures, because "educational crop failure" has been the history of these youngsters during their school experiences.

3. Screening tests as Science Research Achievement Battery, the Iowa Test of Educational Development or the High School Placement Test should be administered. Youngsters with mathematical weaknesses should be evaluated thoroughly by using a good diagnostic test such as the California Test Bureau's, Arithmetic Pre-Diagnostic Battery and the Arithmetic Diagnostic Test Battery, 1955.

   It is simply foolish for teachers to teach what a child already knows.

4. Effective dynamic teaching whether taught by programmed instruction or teaching by the conventional method requires much more than an expensive clerk or a pleasant policeman at the helm. A great teacher teaches with enthusiasm, differentiation, imagination, and professional acuity.

5. Provisions should be made to teach the child what he does not know and to articulate him out of remedial mathematics into challenging courses. Schedule flexibility and flexible course offerings must be provided. Programmed instruction lends itself well to this kind of administration.

6. Basic Mathematics teachers (remedial mathematics) must be fully aware of the negative attitudes of their youngsters. An almost trite adage, "Nothing Breeds Success Like Success Itself" is tremendously important. Admonition has little place in the schedule; firmness, yes! admonition, no!

   The teacher must be proud that he can teach the group. If the teacher does not feel absolutely convinced that what he is doing is no more than "storing-the-dunder-heads" his attitudes soon transfers to the student. By the same token, "Nothing Breeds Defeat like Deafeatism Itslef." The teacher must restore pride and a feeling of victory in his students.

CONCLUSIONS

Temac Programmed Basic Mathematics has advantages.

Those advantages most apparent are:

1. It provides for teachers an opportunity to deal with individual student difficulties yet allows a relatively high per pupil/ teacher ratio.
2. It does help develop reading skills and direction skills.
3. It provides for a youngster to not having "rehash" material he has already learned.
4. It helps the teacher teach absentees
5. It provides better adjustment for late enrollers
6. It provides an opportunity for "remediated students" to proceed in modern algebra, other courses or enrichment programs.
7. It provides the extremely slow youngster an opportunity to learn the various facets of basic mathematics even if he does not finish in one year.

Limitations - Controlled Group - Uncontrolled Group

A child with reading difficulties will not progress satisfactorily in programmed basic mathematics. He will not progress effectively in conventional taught mathematics either.

A wise staff will remedy the reading problem before they attempt mathematics remediation. A child must learn to walk before he can run.

School officials must be willing to modify their use of the Carnegie Unit type of scheduling.